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(54) Combined range laser scanner

Laserabtaster mit kombiniertem Abtastbereich

Dispositif de balayage laser à portée combinée

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to a combined range laser scanner for electro-optically reading indicia such as bar codes having parts of different light reflectivity. More particularly, the subject invention pertains to a combined range laser scanner as described which utilizes two laser diode optical illumination systems focused at different working ranges. One preferred embodiment comprises two laser optical illumination systems, a first system optimized for contact operation, and a second system optimized for longer distance scanning, and the two laser scanning systems are integrated into one combined range laser scanner.

2. Discussion of the Prior Art

The laser scanning system disclosed in U.S. Patent 4,496,831 includes a portable hand-held scanning head which may be embodied in various shapes but preferably has a gun shaped housing made of lightweight plastic. A handle and barrel portion are provided to house the various components of the scanning system therein. Within the barrel portion are mounted a miniature light source, a miniature optic train including focusing lenses and a scanning system for directing light from the light source across a bar code symbol, and miniature sensing means for detecting reflected light from the bar code symbol being scanned.

The miniature light source can comprise a laser tube such as a coaxial helium neon laser tube, or an LED, or preferably a semiconductor laser diode which is considerably smaller and lighter than a laser tube, thus reducing the required size and weight of the scanning head and making the scanning head easier to handle and more maneuverable. Light generated by the light source passes through the optic train which directs the beam onto the scanning system which is mounted within the barrel portion of the scanning head. The scanning system sweeps the laser beam across the bar code symbol and comprises at least one scanning stepping motor or resonating or vibrating bar or scanner for sweeping the beam lengthwise across the symbol, and may comprise two motors wherein the second motor sweeps the beam widthwise across the symbol. Light reflecting mirrors are mounted on the motor shaft or shafts to direct the beam through the outlet port to the symbol.

A sensing circuit then detects and processes the light reflected from the symbol and generally comprises a photodetector element such as a semiconductor photodiode. The user positions the hand-held unit so the scan pattern traverses the symbol to be read, and the photodetector element produces serial electrical signals to be processed for identifying the bar code. A signal processing circuit for a bar code produces a signal which is directed to a bar pattern decoder circuit for decoding the bar pattern.

US-A-4,920,255 discloses an automatic incremental focusing scanner system which optically reads a code pattern on an object. The system includes a scanner which directs a beam of radiation onto the object at one of a number of focal lengths. The system further includes a range determining unit for measuring the range of the object relative to the scanner.

US-A-3,989,348 discloses an optical scanner for focusing an optical beam on a surface, which may be at any of a range of distances, utilizing a plurality of optical plates. The plates, which are of different thicknesses, are selectively insertable in the optical beam path to focus the beam at the surface according to the particular distance thereof.

SUMMARY OF THE INVENTION

Accordingly, it is a primary object of the present invention to provide a combined range laser scanner for electro-optically reading indicia such as bar codes having parts of different light reflectivity which utilizes two or more laser diode optical illumination systems optimally focused for different working ranges and which is cheap to manufacture and particularly useful in hand-held applications. In order to achieve the above object, the present invention provides a combined range laser scan assembly as referred to in independent claim 1.

Preferred embodiments of the present invention are disclosed in the dependent claims.

One disclosed preferred embodiment comprises two laser optical illumination sytems, a first laser illumination system optimized for contact operation and having a range extending to approximately two feet, and a second laser illumination system optimized for longer range scanning from approximately two to seventeen feet, and the two laser scanning systems are integrated into one combined range laser scanner.

Depending upon which laser illumination system is selected, the laser spot speed (e.g. amplitude of the drive signal for the scanning motor) is controlled to limit the frequency of received light signals to that of standard signal processing and decoding circuits. Scanning is achieved with a common oscillating mirror element driven by a scanning motor, and accordingly the amplitude of the applied scanning motor driving signal should be greater for the first laser illumination system optimized for contact or short range operation and less for the second laser illumination system for longer range scanning.

The laser scanning system includes a single common scanning mirror for causing a laser beam to be scanned over a field of view, and short and long range laser illumination optical systems for respectively short or long range scanning operations. A collection optical system is provided for collecting light reflected from the

scanned field of view and directing it onto an optical detector which detects the reflected laser radiation and generates electrical signals corresponding to the reflected light.

In one disclosed embodiment, the scanning mirror includes a flat scanning mirror which is driven by a scanning motor. The short range laser illumination optical system comprises a short range visible laser diode assembly positioned directly in front of the scanning mirror. The longer range laser illumination optical system includes a fold mirror positioned adjacent the short range visible laser diode, and a long range visible laser diode assembly positioned to direct laser radiation to the fold mirror for reflection onto the scanning mirror.

In one preferred embodiment, the short range laser illumination system and longer range laser illumination system could comprise a single integrated laser diode assembly designed to operate in either a short or longer range mode of operation positioned directly in front of the scanning mirror.

The short range laser illumination system preferably has a range from contact up to approximately two feet from the laser scanner, whereas the longer range laser illumination system has a range of approximately two feet to seventeen feet from the laser scanner assembly. The collection optical system includes a single common collection mirror which focuses all scanned laser radiation reflected from the field of view onto an optical detector such as a photodiode.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing objects and advantages of the present invention for a combined range laser scanner may be more readily understood by one skilled in the art with reference being had to the following detailed description of several preferred embodiments thereof, taken in conjunction with the accompanying drawings wherein like elements are designated by identical reference numerals throughout the several views, and in which:

Figure 1 illustrates scanning decoding zone ranges for different bar code resolutions for a combined dual short and long range scanner of the present invention;

Figure 2 is a block diagram of the major functions and components of a first embodiment of a combined dual short and long range scanner pursuant to the present invention;

Figure 3 illustrates a schematic view of an exemplary arrangement of an optical system for a combined dual short and long range scanner of the subject invention;

Figure 4 illustrates a side elevational view of an exemplary optical system for a combined dual short and long range scanner of the subject invention;

Figure 5 is a front elevational view of the exemplary optical system of Figure 5;

Figures 6A and 6B illustrate sectional views of a laser diode assembly illustrating the construction and major components thereof; and

Figure 7 illustrates a highly simplified type of bar code reader which can be utilized in association with the combined range laser scanner of the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring to the drawings in detail, Figure 1 illustrates scanning decoding zone ranges for different bar code resolutions for high quality bar code symbols at 20°C for a combined dual short and long range scanner pursuant to the present invention. A short range decoding zone provides for reading bar code patterns from contact to approximately 0.6 m (two feet), while a long range decoding zone provides for reading bar code patterns from approximately 0.6 m to 5.18 m (two to seventeen feet). As indicated by Figure 1, the resolution attainable for bar code patterns ranges from a 0.13 mm (0.005 inch) bar width for bar code patterns at a very close range to a 1.3 mm (0.050) inch bar width for bar code patterns at a distant range. An overlapping range exists in the region between the short and long range decoding zones, and in fact the short range decoding zone extends out to approximately 1.37 m (four and one half feet), while the long range decoding zone extends from approximately 0.25 m (ten inches) to approximately 6.10 m (twenty feet), but decoding operations performed outside the more restricted ranges mentioned hereinabove are not optimized.

Figure 2 is a block diagram of the major functions and components of an embodiment of a combined dual short and long range scanner assembly pursuant to the present invention. In this embodiment, either the short or long range laser diode is selectively activated by an operator actuating a trigger 12 having first and second detent trigger positions as follows. In operation, for long range operation, the trigger is initially activated to a first detent position. Logic switching circuitry 32 in the combined dual range scanner selects the long range laser diode and selects an appropriate aim scan amplitude for the scanner motor for operation in an aiming mode. In an aiming mode, as is known in the art, a flat scanning mirror is first activated to oscillate slowly, producing a horizontal scan line of the visible laser beam which is used by the operator to aim the scanner at distances up to 18 feet.

The trigger is then activated to a second detent position. The logic circuitry 16 selects the long range laser beam and long range scan amplitude based upon the long dwell time at the first trigger detent position. After the trigger is depressed to the second detent position, the flat scanning mirror is then oscillated at its normal long range scan frequency and width, and a detection circuit is enabled. The light reflected back into a curved

collection mirror is focused onto a photodetector and amplified to a signal that is then digitized into a digital signal which is processed by a decoder. Scanning is achieved with a common oscillating flat mirror element driven by a scanning motor, and accordingly the amplitude of the applied scanning motor driving signal should be greater for the first laser illumination system optimized for contact or short range operation and less for the second laser illumination system for longer range scanning. The different scanning speeds limit the frequency of received light signals to that of standard signal processing and decoding circuits.

For short range operation, an operator aims the scanner at a short range bar code (from contact to 0.61 m (24")). The trigger is then actuated by pulling it directly to the second detent position of the trigger switch. The logic circuitry 32 selects the short range laser 20 and short range scan amplitude based upon the minimal dwell time at the first trigger detent position. The scanning mirror is first actuated in an aiming mode in which the scanning motor oscillates slowly to produce a visible horizontal scan line which is used by the operator to aim the scanner. The scanning mirror is then oscillated at its normal short range scan frequency and width, and the detection circuit is enabled. The light reflected back into the collection mirror is focused onto the photodetector and amplified to a signal that is then digitized into a digital signal which is processed by a bar code decoder circuit.

In one preferred embodiment, the short range laser illumination system and longer range laser illumination system could comprise a single integrated laser diode assembly designed to operate in either a short or longer range mode of operation positioned directly in front of the scanning mirror. In an alternative preferred embodiment, the short and longer range illumination systems comprise separate short range and longer range laser diode assemblies as illustrated in Figures 3, 4 and 5.

The selected solid state laser diode generates a laser beam, and focusing optics in the laser diode assembly transmits the laser beam to a flat scanning mirror that is oscillated to cause the laser beam to be swept across the scanned bar code pattern. Scanning is achieved with a common oscillating flat mirror element driven by a scanning motor, and because of the short distance to a short range bar code target, the amplitude of the applied scanning motor driving signal should be greater for the first laser illumination system optimized for contact or short range operation, and conversely because of the longer distance to a long range bar code target, it should be less for the second laser illumination system for longer range scanning. The different scanning speeds limit the frequency of received light signals to that of standard signal processing and decoder circuits. The oscillating scanner mirror reflects the laser light beam through an exit window to the bar code symbol. Typically, the laser beam is scanned back and forth across the bar code symbol at approximately 36 times a second. An optical detector senses the laser light reflected back from the bar code symbol, and converts the light signals into an analog signal which is processed by analog circuitry 22 in a manner as known in the art and disclosed by prior art patents cited herein. The pattern of the analog signal represents the information in the bar code symbol.

Signal conditioning circuits in a digitizer circuit 24 convert the analog signal into a digitized bar pattern signal, also in a manner as known in the art, and this pattern is transmitted to an interface controller module in a console 26 for decoding.

Figure 3 illustrates a schematic view of an exemplary arrangement of an optical system for a combined dual short and long range scanner assembly of the subject invention. A short range visible light laser diode assembly 40 and long range visible light diode assembly 42 are shown schematically positioned on opposite sides of a photodiode detector 44 which detects laser radiation directed thereto by a collection mirror 46. In alternative embodiments, the positioning of the elements 40, 42 and 44 may be varied in different geometric arrangements.

Figures 4 and 5 illustrate respectively a side elevational view and a front elevational view of an exemplary optical system for a combined dual short and long range scanner assembly pursuant to the subject invention. Referring thereto, a short range visible ligh laser diode assembly 50 is positioned near the front of a reader gun 52 directly in front of a flat scanning mirror 54 which is oscillated by a scanning motor 56 and drive mechanism 58. A long range flat fold mirror 60 is positioned adjacent to the laser diode assembly 50, and is illuminated by a long range visible light laser diode assembly 62 mounted on a heat sink 64 positioned adjacent the flat scanning mirror 54 in the rear of the gun housing. Laser radiation from laser diode 62 is directed to the fold mirror 60 which reflects it onto the oscillating scanning mirror 54, which directs it through the exit aperture of the gun.

Laser radiation reflected by the bar code pattern is received and collected by a curved collection mirror 66, which reflects and focuses it to a photodiode detector 68. The flat scanning mirror 54 and curved collected mirror 66 are preferably formed as one integral mirror element as shown in Figure 5 which is driven by the scanning motor 56 in a manner as is known in the art.

Figure 6 illustrates a sectional view of a typical laser diode assembly illustrating the construction and major components thereof. Referring thereto, a typical laser diode assembly 70 comprises an assembly housing 72 having a visible light laser diode package 74 at one end, and a lens spring biased by a spring 76 against a focusing lens 78 at the opposite end of the housing. A central aperture 80 in the opposite end of the housing allows a laser beam focused at an appropriate distance by the lens 78 to exit as the laser beam. In the short range laser diode assembly, the lens 78 focuses the laser beam for short range scanning operations, whereas in the longer

range laser diode assembly, the lens 78 focuses the laser beam for longer range scanning operation.

In one preferred embodiment, the short range laser illumination system and longer range laser illumination system could comprise a single integrated laser diode assembly designed to operate in either a short or longer range mode of operation positioned directly in front of the scanning mirror such as at the position of the short range laser diode assembly 60 in Figures 4 and 5. In this embodiment, two laser apertures 80' and 80' are positioned adjacent to each other on opposite sides of the center of the assembly as shown in phantom in Figure 6, the lens is formed as one integral lens having two different focusing surfaces divided down the center as indicated by phantom line 82 in Figure 6, such that a different curvature lens surface, one for near focusing and one for far focusing, is positioned in front of each of the two different exit apertures 80', 80'. The laser diode package 74 would house two different laser diodes, one positioned directly behind each laser aperture 80', 80'. It should be realized that the laser diode element itself is extremely small, such that the side-by-side positioning of two such laser diodes in the laser diode package 74 is easily accommodated.

Figure 7 illustrates a highly simplified type of bar code reader that may be utilized in association with the combined range laser scanner assembly, and which is useful in understanding the invention. A reader 100 may be implemented in a hand-held scanner, as illustrated, or a desk-top workstation or stationery scanner. In a preferred embodiment, the arrangement is implemented in a housing 155 that includes an exit port 156 through which an outgoing laser light beam 151 is directed to impinge on, and to be scanned across, symbols 170 located exteriorly of the housing.

The hand-held device of Figure 7 is generally of the style disclosed in U.S. Patent 4,760,248.

Referring to Figure 7 in more detail, an outgoing light beam 151 is generated in the reader 100, usually by a laser diode or the like, and directed to impinge upon a bar code symbol disposed on a target a few inches from the front of the reader unit. The outgoing beam 151 is scanned in a scan pattern, and the user positions the hand-held unit so this scan pattern traverses the symbol to be read. Reflected light 152 from the symbol is detected by a light-responsive device 158 in the reader unit, producing serial electrical signals to be processed and decoded for reproducing the data represented by the bar code.

In a preferred form, the reader unit 100 is a gun shaped device having a pistol-grip type of handle 153, and movable trigger 154 is employed to allow the user to activate the light beam 151 and detector circuitry when pointed at the symbol to be read, thereby saving battery life if the unit is self-powered. A lightweight plastic housing 155 contains the laser light source, the detector 158, the optics and signal processing circuitry, and the CPU 140 as well as power source or battery 162. A light-transmissive window 156 in the front end of the housing 155 allows the outgoing light beam 151 to exit and the incoming reflected light 152 to enter. The reader 100 is designed to be aimed at a bar code symbol by the user from a position in which the reader 100 is spaced from the symbol, i.e., not touching the symbol or moving across the symbol. Typically, this type of hand-held bar code reader is specified to operate in the range of perhaps several inches (1 inch = 2.54 cm).

The reader 100 may also function as a portable computer terminal, and include a keyboard 148 and a display 149, such as described in U.S. Patent 4,409,470.

As further depicted in Figure 7, a suitable lens 157 (or multiple lens system) may be used to focus the scanned beam onto the bar code symbol at an appropriate reference plane. A light source 146 such as a semiconductor laser diode is positioned to introduce a light beam into the axis of the lens 157, and the beam passes through a partially silvered mirror 147 and other lenses or beam-shaping structure as needed, along with an oscillating mirror 159, which is attached to a scanning motor 160 activated when the trigger 154 is pulled. If the light produced by the source 146 is not visible, an aiming light may be included in the optical system. The aiming light, if needed, produces a visible-light spot which may be fixed, or scanned just like the laser beam; the user employs this visible light to aim the reader unit at the symbol before pulling the trigger 154.

Claims

1. A combined range laser scanner assembly for electro-optically reading indicia (170) having parts of different light reflectivity, comprising:

   a. a laser scanning system including a scanning mirror (54) for causing a laser beam to be scanned over a field of view;
   b. a short range laser illumination system (50) for short range scanning operations;
   c. a long range, longer than the short range, laser illumination system (62) for long range scanning operations;
   d. a collection optical system (66) for collecting light reflected from the scanned field of view; and
   e. an optical detector (68) for detecting light directed thereto by the collection optical system and for generating electrical signals corresponding to the reflected light characterized by

   a manually operable switching means for selectively activating the short range laser illumination system for operation at short ranges in the field of view, and for selectively activating the long range laser illumination system for operation at long ranges in

the field of view.

2. The scanner assembly as claimed in claims 1, wherein said manually operable switching means includes a trigger means (12) for the laser scanner assembly.

3. The scanner assembly as claimed in claim 2, wherein said trigger means (12, 154) includes first and second trigger detent positions which are selectively actuated by an operator.

4. The scanner assembly as claimed in claim 1, wherein said scanning mirror (54) is a flat mirror which is driven by a scanner motor (56).

5. The scanner assembly as claimed in any of claims 1 to 4, wherein said collection optical system includes a collection mirror (66) which focuses scanned laser radiation reflected from the field of view onto said optical detection (58).

6. The scanner assembly as claimed in any of claims 1 to 5, wherein said short range laser illumination system (50) includes a short range visible beam laser diode (50) positioned in front of said scanning mirror (54).

7. The scanner assembly as claimed in claim 6, wherein said long range laser illumination system includes a folding mirror (60) positioned by the short range visible beam laser diode (50), and a long range visible beam laser diode (62) positioned to direct laser radiation to said folding mirror (60) for reflection of the laser radiation onto said scanning mirror (54).

Patentansprüche

1. Laser-Scanner-Anordnung mit kombiniertem Bereich zum elektro-optischen Lesen von (Kenn-)Zeichen (170) mit Teilen mit unterschiedlichem Lichtreflexionsvermögen, wobei die Anordnung folgendes aufweist:

   a. ein Laser-Scan- bzw. -Abtast-System mit einem Scan- bzw. Abtastspiegel (54) zum Bewirken, daß ein Laserstrahl über ein Sichtfeld hinweg gestrichen bzw. gescannt wird;
   b. ein Kurzstrecken- bzw. Nahbereichslaserbeleuchtungssystem (50) für Kurzstrecken- bzw. Nahbereichs-Scan- bzw. -Abtastvorgänge;
   c. ein Langstrecken- bzw. Fernbereichslaserbeleuchtungssystem (62), und zwar für eine Langstrecke bzw. einen Fernbereich, die bzw. der länger bzw. weiter entfernt ist als die Kurzstrecke bzw. der Nahbereich, für Langstrecken- bzw. Fernbereichs-Scan-bzw. -Abtastvorgänge;
   d. ein optisches Sammelsystem (66) zum Sammeln von Licht, das von dem gescannten Sichtfeld reflektiert wird; und
   e. einen optischen Detektor (68) zum Detektieren von Licht, das von dem optischen Sammelsystem dorthin geleitet wird, und zum Erzeugen elektrischer Signale entsprechend dem reflektierten Licht,

   gekennzeichnet durch
   manuell betätigbare Schaltmittel zum selektiven Aktivieren des Nahbereichslaserbeleuchtungssystems zum Betrieb in nahen oder kurzen Bereichen im Sichtfeld, und zum selektiven Aktivieren des Fernbereichslaserbeleuchtungssystems zum Betrieb in fernen oder langen Bereichen im Sichtfeld.

2. Scanner-Anordnung gemäß Anspruch 1, wobei die manuell betätigbaren Schaltmittel Auslöse- oder Triggermittel (12) für die Laser-Scanner-Anordnung umfassen.

3. Scanner-Anordnung gemäß Anspruch 2, wobei die Auslöse- oder Triggermittel (12, 154) erste und zweite Auslöse- oder Trigger-Rastpositionen umfassen, die durch einen Bediener selektiv betätigt werden.

4. Scanner-Anordnung gemäß Anspruch 1, wobei der Scan- bzw. Abtastspiegel (54) ein flacher Spiegel ist, der von einem Überstreich- bzw. Scanner-Motor (56) angetrieben wird.

5. Scanner-Anordnung gemäß einem der Ansprüche 1 bis 4, wobei das optische Sammelsystem einen Sammelspiegel (66) umfaßt, der die von dem Sichtfeld reflektierte, gescannte Laserstrahlung auf den optischen Detektor (58) fokussiert.

6. Scanner-Anordnung gemäß einem der Ansprüche 1 bis 5, wobei das Nahbereichslaserbeleuchtungssystem (50) eine Nah- oder Kurzbereichs-Laserdiode (50) mit sichtbarem Strahl umfaßt, die vor dem Scan- bzw. Abtastspiegel (54) angeordnet ist.

7. Scanner-Anordnung gemäß Anspruch 6, wobei das Fernbereichslaserbeleuchtungssystem einen bei der Nah- oder Kurzbereichs-Laserdiode (50) mit sichtbarem Strahl angeordneten Faltungsspiegel (60) und eine Fern- oder Langbereichs-Laserdiode (62) mit sichtbarem Strahl umfaßt, die zum Leiten von Laserstrahlung zum dem Faltungsspiegel (60) angeordnet ist, und zwar für eine Reflexion der Laserstrahlung auf den Scan- bzw. Abtastspiegel (54).

Revendications

1. Assemblage de dispositif à balayage laser de portée combinée pour une lecture électro-optique d'indices (170) comportant des parties de différents pouvoirs de réflexion de la lumière, comprenant :

   a. un système à balayage laser comportant un miroir (54) à balayage pour conduire un faisceau laser à être balayé sur un champ de vision ;
   b. un système (50) d'éclairage laser de courte portée pour des opérations de balayage à courte portée ;
   c. un système (62) d'éclairage laser de longue portée, plus longue que la courte portée, pour des opérations de balayage de longue portée ;
   d. un système (66) optique de collecte pour collecter la lumière réfléchie par le champ de vision balayé ; et
   e. un détecteur optique (68) pour détecter la lumière dirigée vers lui par le système optique de collecte et pour générer des signaux électriques correspondant à la lumière réfléchie, caractérisé par

   un moyen de commutation pouvant être actionné manuellement pour activer sélectivement le système d'éclairage laser de courte portée pour un fonctionnement à de courtes portées dans le champ de vision, et pour activer sélectivement le système d'éclairage laser de longue portée pour un fonctionnement à de longues portées dans le champ de vision.

2. Assemblage de dispositif à balayage selon la revendication 1, dans lequel ledit moyen de commutation pouvant être actionné manuellement comporte un moyen de déclenchement (12) pour l'assemblage de dispositif à balayage laser.

3. Assemblage de dispositif à balayage selon la revendication 2, dans lequel ledit moyen de déclenchement (12, 154) comporte des première et deuxième positions de détente de déclenchement qui sont actionnées sélectivement par un opérateur.

4. Assemblage de dispositif à balayage selon la revendication 1, dans lequel ledit miroir à balayage (54) est un miroir plat qui est actionné par un moteur (56) de dispositif à balayage.

5. Assemblage de dispositif à balayage selon l'une quelconque des revendications 1 à 4, dans lequel ledit système optique de collecte comporte un miroir de collecte (66) qui focalise le rayonnement laser balayé réfléchi par le champ de vision sur ledit détecteur optique (58).

6. Assemblage de dispositif à balayage selon l'une quelconque des revendications 1 à 5, dans lequel ledit système (50) d'éclairage laser de courte portée comporte une diode laser (50) à faisceau visible de courte portée, placée en face dudit miroir à balayage (54).

7. Assemblage de dispositif à balayage selon la revendication 6, dans lequel ledit système d'éclairage laser de longue portée comporte un miroir de repliement (60) positionné par la diode laser (50) à faisceau visible de courte portée et une diode laser (62) à faisceau visible de longue portée positionnée pour diriger un rayonnnement laser vers ledit miroir de repliement (60) pour une réflexion du rayonnement laser sur ledit miroir à balayage (54).

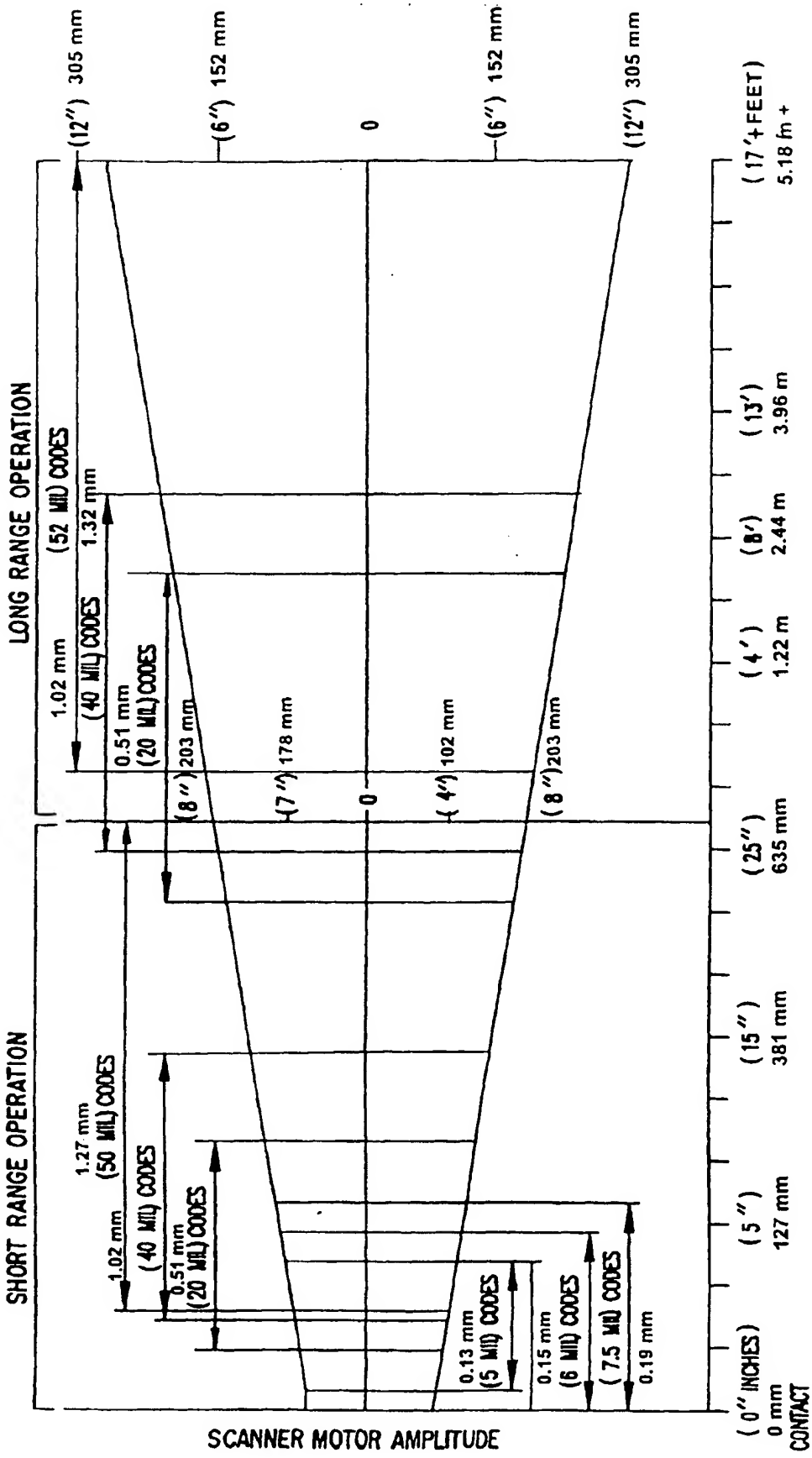
LONG RANGE OPERATION
SHORT RANGE OPERATION
SCANNER MOTOR AMPLITUDE
(12") 305 mm
(6") 152 mm
0
(6") 152 mm
(12") 305 mm
1.02 mm (40 MIL) CODES
0.51 mm (20 MIL) CODES
1.32 mm (52 MIL) CODES
1.27 mm (50 MIL) CODES
(8") 203 mm
(7") 178 mm
(4") 102 mm
0.13 mm (5 MIL) CODES
0.15 mm (6 MIL) CODES
0.19 mm (7.5 MIL) CODES
(0" INCHES) 0 mm CONTACT
(5") 127 mm
(15") 381 mm
(25") 635 mm
(4') 1.22 m
(8') 2.44 m
(13') 3.96 m
(17'+FEET) 5.18 m+

FIG. 1

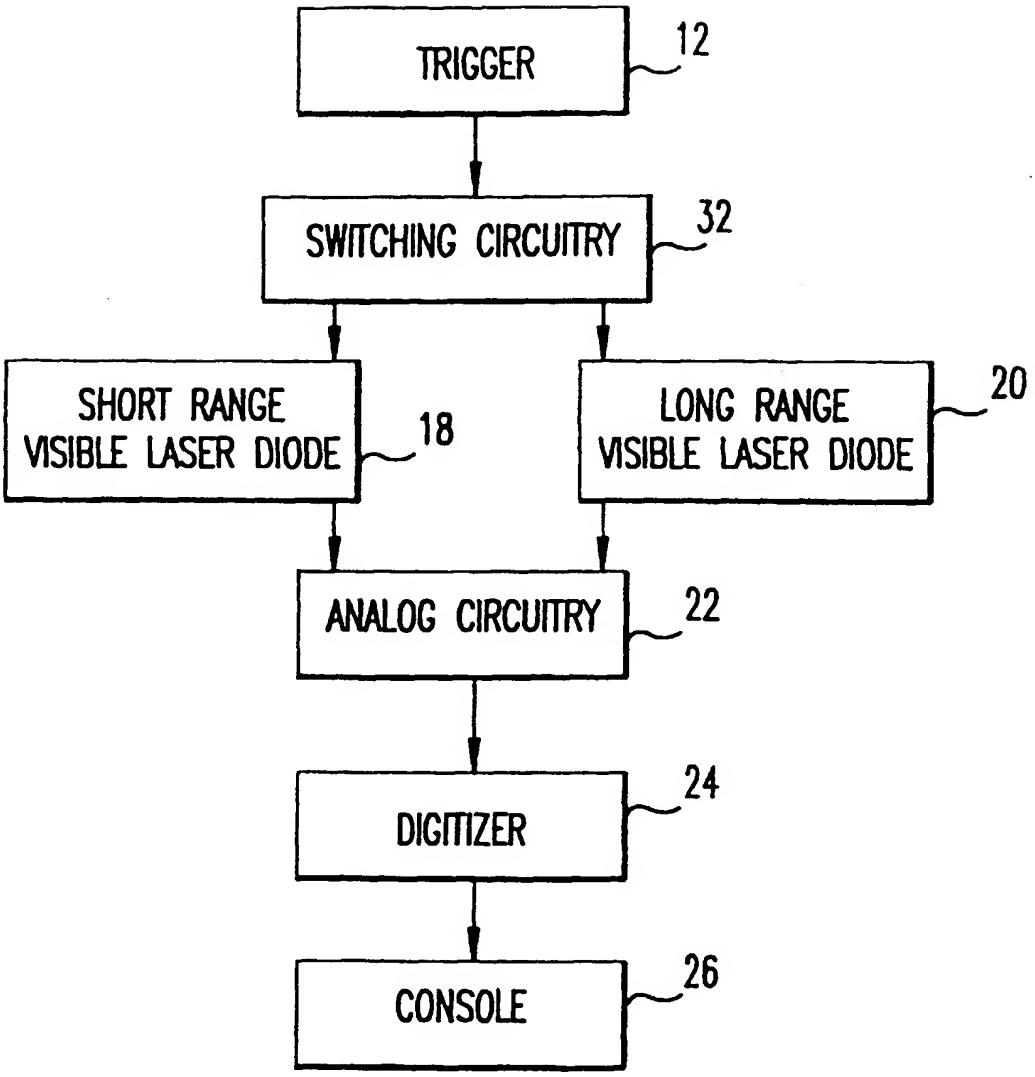
TRIGGER
12
SWITCHING CIRCUITRY
32
SHORT RANGE VISIBLE LASER DIODE
18
LONG RANGE VISIBLE LASER DIODE
20
ANALOG CIRCUITRY
22
DIGITIZER
24
CONSOLE
26

Fig. 2

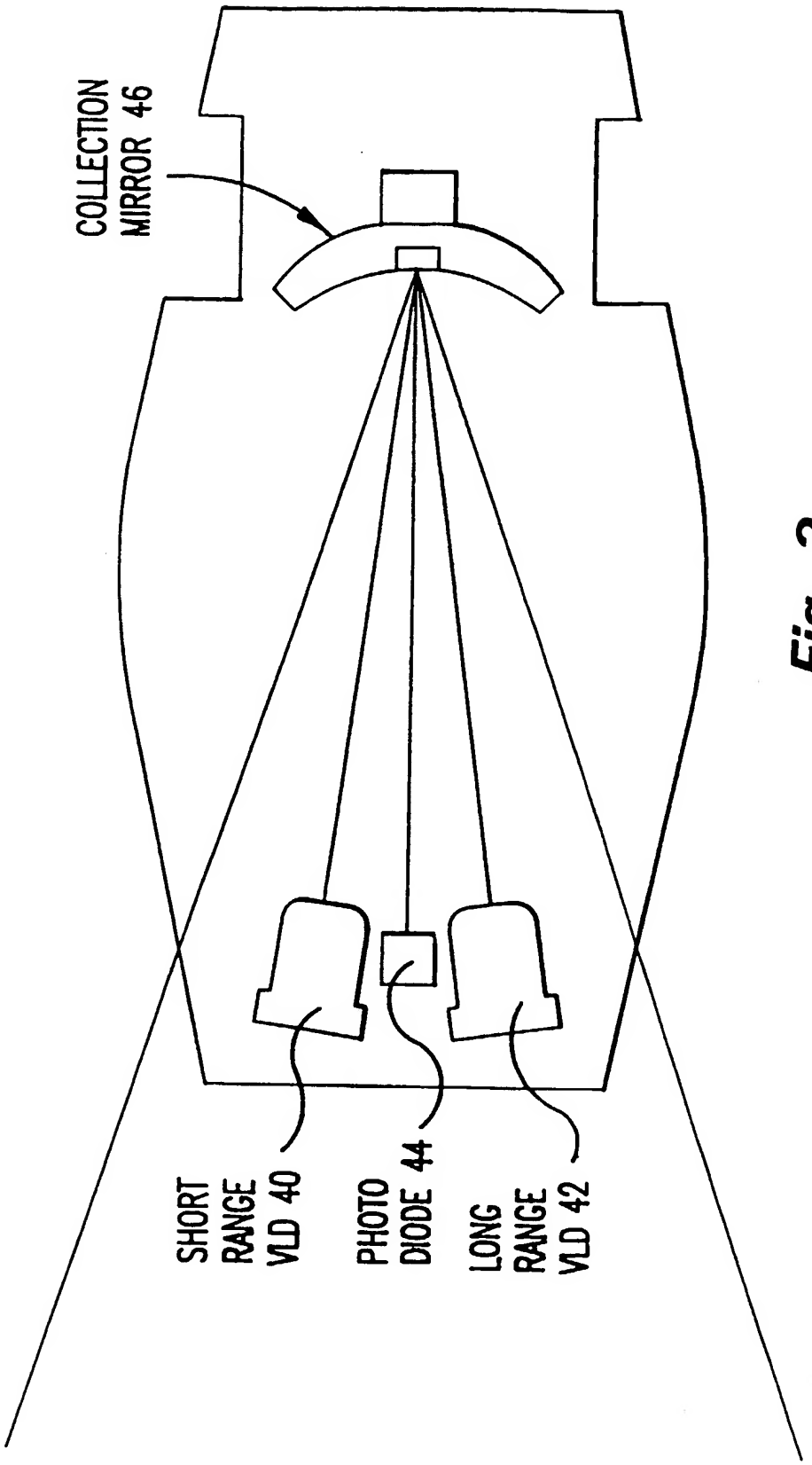
COLLECTION MIRROR 46
SHORT RANGE VLD 40
PHOTO DIODE 44
LONG RANGE VLD 42

Fig. 3

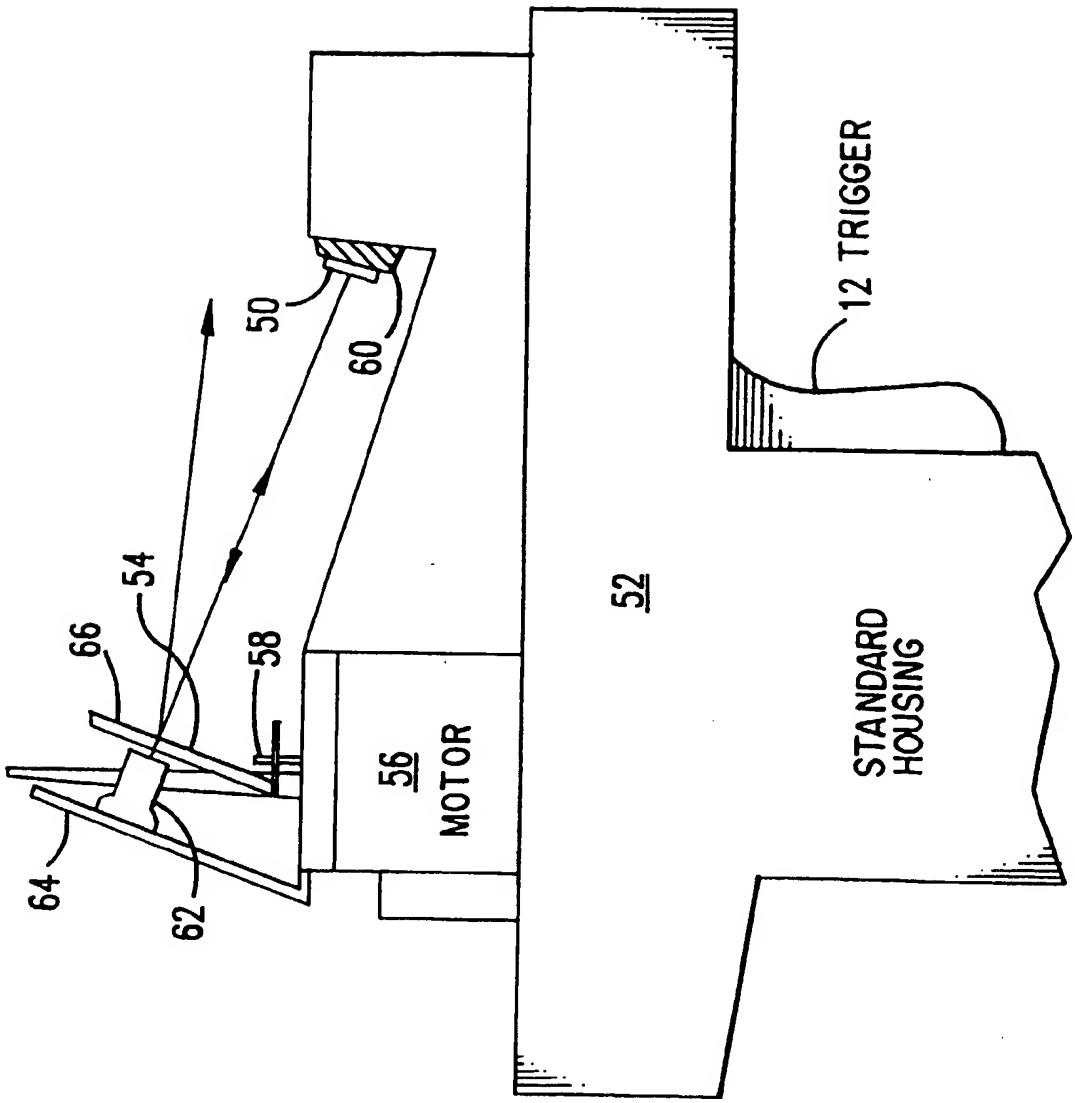

Fig. 4

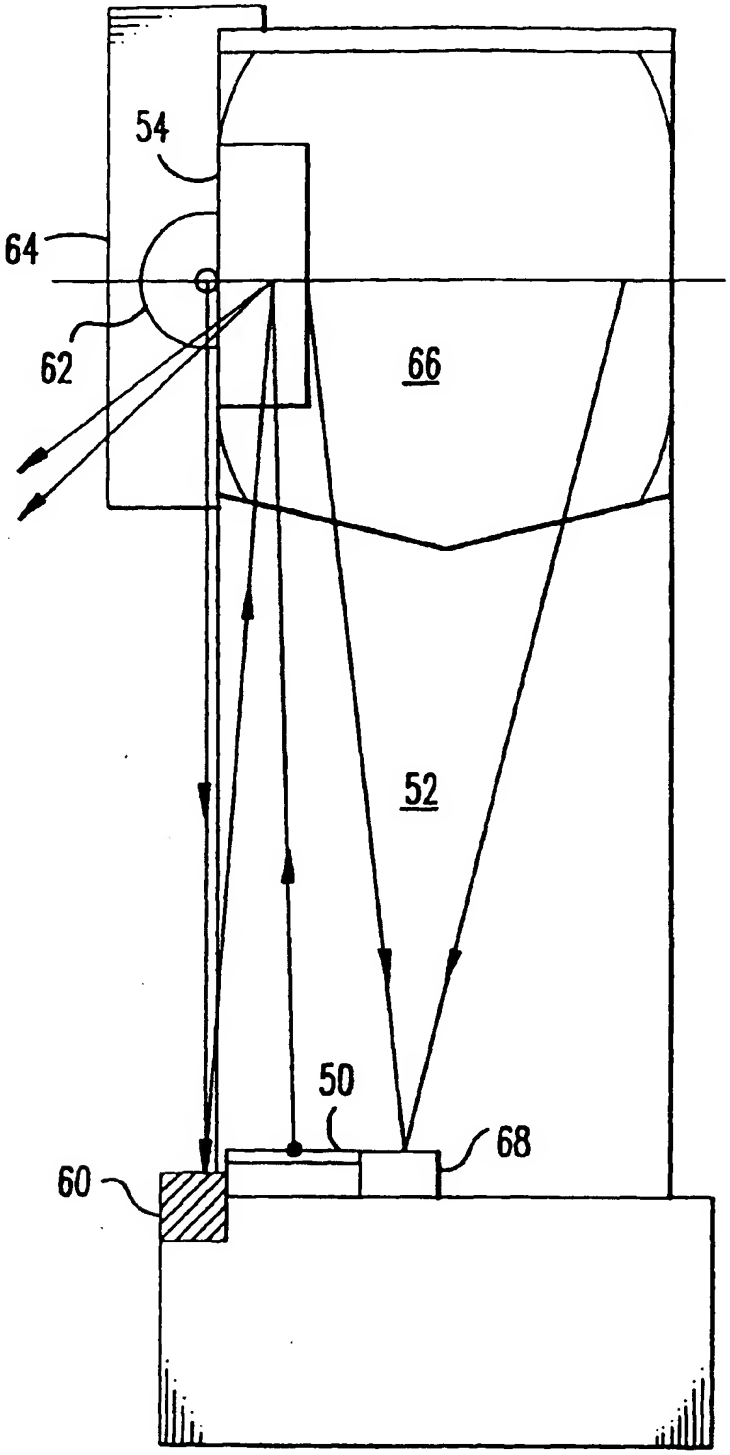

Fig. 5

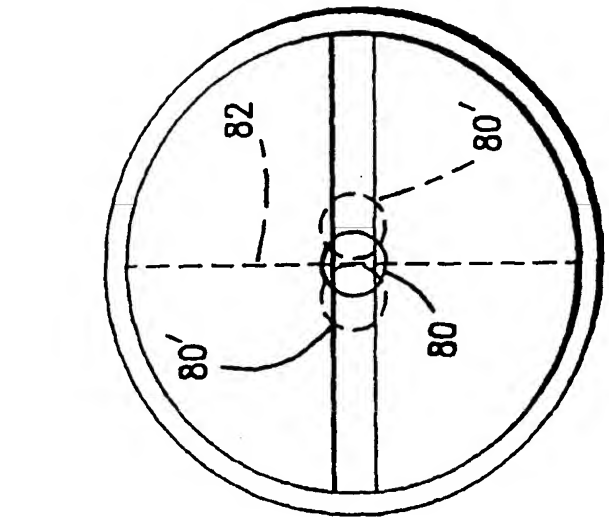

Fig. 6B

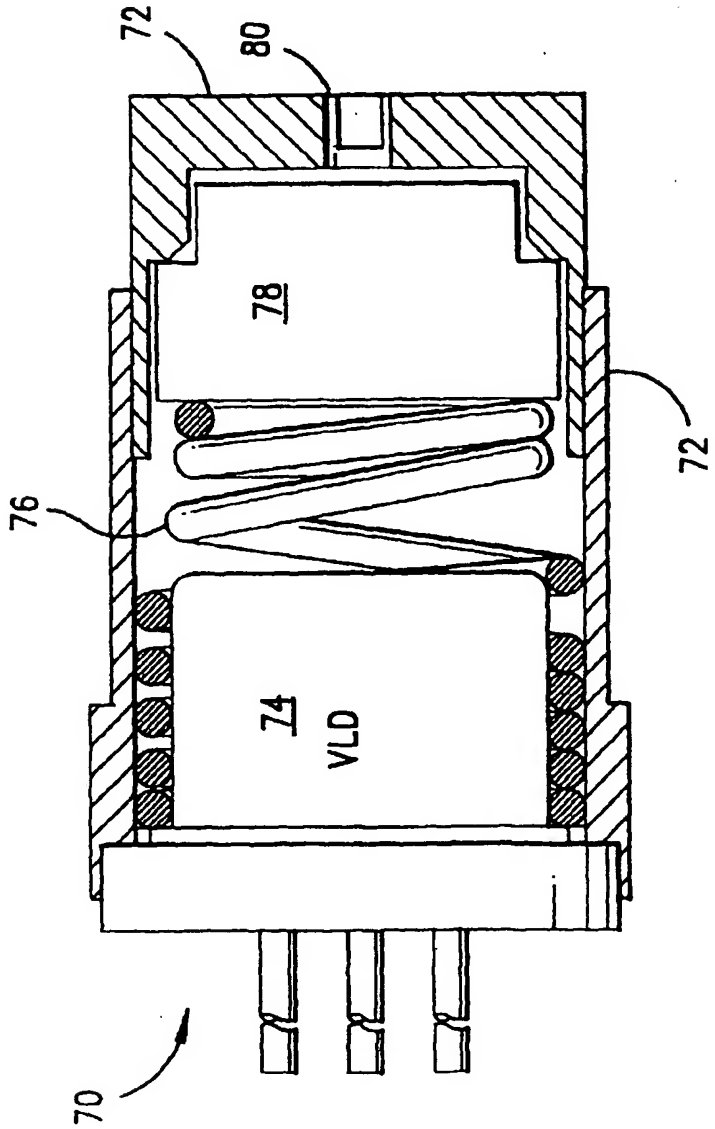

Fig. 6A

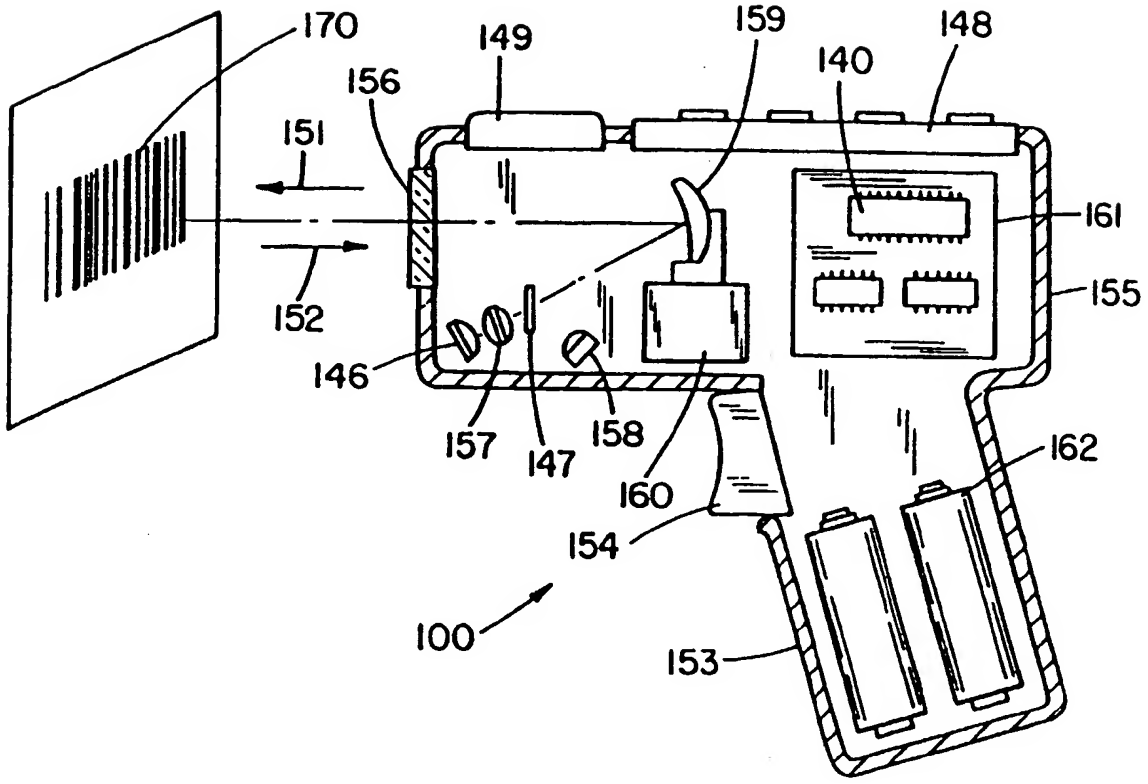
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Fig. 7